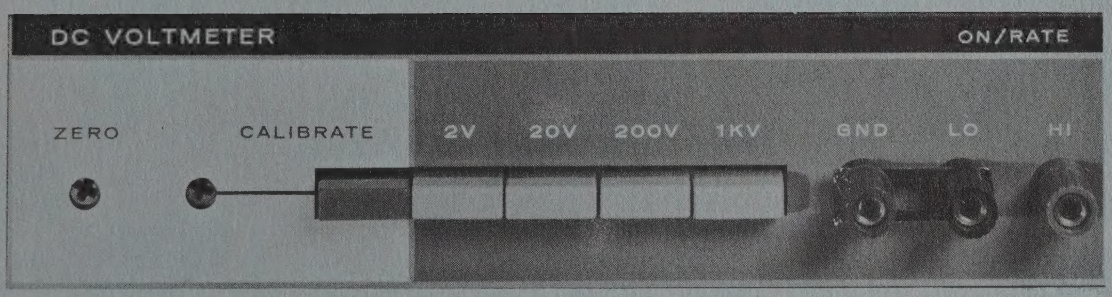
R. E. Albrecht
Dec 25, '

DIGIEC

VOLTMETER PLUG-IN MODULE INSTRUCTION MANUAL

MI-944A

FOR MODELS
251-1 & 252-1



SUPERSEDES MI-817 & 869

UNITED SYSTEMS CORPORATION

918 WOODLEY ROAD/ DAYTON, OHIO 45403 /

MP MASTER
MA26185

SHIPPING INSTRUCTIONS

If it should become necessary to return the instrument to United Systems Corporation, make certain that at least four inches of padding material surrounds the instrument to prevent damage during shipment. When returning instruments to the factory, give a full description of the failure of the instrument and the mode of operation that was used when the instrument failure occurred. Ship via REA Express, motor truck, or air freight PREPAID to:

United Systems Corporation
918 Woodley Road
Dayton, Ohio 45403.

For foreign countries: Please contact your local representative for instructions.

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United Systems Corporation guarantees this instrument to be free from defects in workmanship and materials. This guarantee is limited to servicing or adjusting an instrument returned to the factory for that purpose, and to repairing, replacing or adjusting all parts which shall, within one year after making delivery to the original purchaser, be returned by the original purchaser with transportation charges prepaid, and which, upon our examination, shall disclose to our satisfaction to have been thus defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at a nominal cost. In this case, an estimate will be submitted before work is started.

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TABLE OF CONTENTS

1.	GENERAL INFORMATION	
1.1	Features	Page 4
1.2	Applications	Page 4
1.3	Instrument Identification	Page 4
1.4	Technical Characteristics	Page 5
2.	OPERATION	
2.1	Function of Controls	Page 6
2.2	Turn-on Procedure	Page 7
2.2.1	Warm-up Period	Page 7
2.2.2	Zero Adjustment	Page 7
2.2.3	Calibrate Adjustment	Page 7
2.2.4	Overrange Blanking	Page 9
2.2.5	Differential DC Voltage Measurement	Page 9
2.3	Possible Sources of Error	Page 9
2.3.1	Ground Loop Precaution	Page 9
2.3.2	Loading Error	Page 9
2.3.3	Environment	Page 10
2.4	Use of a Converter for AC Voltage Measurement	Page 10
3.	AC INTERFERENCE	
3.1	Normal Input	Page 10
3.2	Fast Input	Page 11
3.3	Twin "T" Filter Only	Page 11
4.	CIRCUIT DESCRIPTION	
4.1	Notch Filter	Page 12
4.2	Input Attenuator	Page 12
4.3	Low-Pass Filter	Page 12
4.4	Overload Protection	Page 12
4.5	Ramp Generator	Page 15
4.6	Dual Comparator	Page 15
4.7	Exclusive "OR"	Page 15
4.8	Crystal Oscillator	Page 16
4.9	Gated Frequency Divider	Page 16
4.10	Polarity Flip Flop	Page 16
5.	MAINTENANCE	
5.1	Necessary Maintenance Equipment	Page 16
5.2	Periodic Test (1000 hours or 6 months)	Page 16
5.2.1	Symmetry	Page 18
5.2.2	Calibration	Page 18

6. SERVICE AND TROUBLESHOOTING

6.1 Troubleshooting Hints Page 20
6.2 Ramp Generator Page 20
6.3 Comparator Page 21
6.4 Exclusive "OR" Gate Page 21
6.5 Oscillator Page 21
6.6 Frequency Divider Page 21
6.7 Polarity Flip Flop Page 21

7. TROUBLESHOOTING CHART

ILLUSTRATIONS & DIAGRAMS

Figure 1.	Complete 251 and 251-1	Page 8
Figure 2.	252-1 Plug-In	Page 8
Figure 3.	Block Diagram 251-1	Page 13
Figure 4.	Block Diagram 252-1	Page 14
Figure 5.	Bottom of Plug-In	Page 17
Figure 6.	Troubleshooting Flow Chart	Page 23
Figure 7.	Bottom of Plug-In Showing Fast and Slow Connections	Pages 24 and 25
Figure 8.	Schematic of Model 251-1	Page 26
Figure 9.	Parts List for 251-1	Pages 27 and 28
Figure 10.	Schematic of Model 252-1	Page 29
Figure 11.	Parts List for 252-1	Pages 30 and 31
Figure 12.	Timing Diagram	Page 32
Figure 13.	Picture of 251-1 Showing Components	Page 33
Figure 14.	Picture of 252-1 Showing Components	Page 34

1. GENERAL INFORMATION

1.1 Features

The Model 251-1 or 252-1 Plug-In Modules when used in conjunction with a Series 251 or 252 Main Frame become highly accurate and precise multi-range digital voltmeters.

Some of the important features of the 251-1 and 252-1 Plug-In Modules are:

High accuracy	Overload protection
Convenient pushbutton range selection	Calibrated overrange
Fast reading time	High input impedance
High AC rejection	Front panel calibration
Overrange blanking	Automatic polarity

Three-terminal input for floating measurements

1.2 Applications

Some of the applications of an instrument using this Plug-In are:

As a working standard,

For high accuracy laboratory measurements,

For high resolution monitoring,

For fast, fatigue-free production line test of DC voltage,

As a direct readout for accelerometers, pressure transducers, etc.,

As a readout device for analog computers,

For calibration checks for moving coil indicators,

For regulation, accuracy and stability test on power supplies.

1.3 Instrument Identification

The instrument model, serial number, and other pertinent data are given on the identification tag on the bottom of the plug-in module. Compatibility between the Main Frame and the interchangeable "Plug-In" Modules is expressed by the first three digits of the Model Number. For example, the Model 251 Main Frame will accept the Model 251-1 Digital Voltmeter Plug-In.

1.4 Technical Characteristics

	251-1	252-1
DC Voltage Range	10.000V	2.000V
	100.00V	20.00V
	1000.0V	200.0V
		1000.0V
Operational Accuracy(1)	Nominally .05% of reading ±1 digit	
Input Impedance	1 meg for 10V range 10 meg for other ranges	10 meg for all ranges
Reading Resolution	1 MV (Lowest range)	

AC Rejection

Frequency	Normal Mode	Common Mode
@ 50Hz	60 Db	80 Db
@ 60Hz	75 Db	80 Db
@ 120Hz	60 Db	80 Db
@ 600Hz	80 Db	80 Db
@ 1200Hz	100 Db	80 Db

Calibrated Overrange(2)	Lower Ranges= 40% Highest Range= to 1000V	Lower Ranges= 50% Highest range= to 1000V
Overload Protection	500V lowest range 1250V other ranges	
	Maximum input voltage of 50V with Fast input on Model 252-1	
Reading Time	Provisions are made on the plug-in module for filtered (Normal) or unfiltered (fast) operation. Filtered reading time is 600Ms maximum to 99.95% rated accuracy.	
Maximum read rate (Ext. interrogate unfiltered input)	Single reading- 80Ms Repetitive- 10/sec	Single reading- 20Ms Repetitive- 20/sec

	251-1	252-1
Operative Ambient	60 - 110°F	
Isolation	500V to case and power line ground	

(1) Stability (after 20-minute warm up)

A. Internal calibration

±.001%/°C

±.02%/6 months

B. Zero

±.0025% of range/°C

±1 digit/day

C. Divider

±.007% of reading/°C

(2) When calibrated overrange is exceeded, nixie indicators will blank and the blanking logic bit comes true.

2. OPERATION (See Figures 1 & 2)

2.1 Function of Controls

Zero Control

Adjust for a digital display of 0000 with the input shorted. If extreme ambient temperatures are encountered, the zero control may need readjustment.

Zero Button

Used to release the input from the attenuator and short the input of the attenuator to ground on Model 251-1.

Calibrate Control

Adjust for a digital display equal to the calibrating voltage when the calibrate button is pushed. Adjust this control, if necessary, to compensate for long term aging drift of the instrument or for variations due to extremely large ambient temperature variations.

2.1 Function of Controls (Cont'd)

Range Switch

Used to change the voltage range of the voltmeter.

Banana Jacks

Red - Input signal high

Black - Input signal low

Green - Chassis ground

Ground Strap

Normally connected between signal "Lo" and "Gnd" to enable the user to operate the voltmeter as a single ended instrument.

2.2 Turn-On Procedure

2.2.1 Warm-up Period

Turn "On/Rate" Control on the main frame to the fully clockwise (maximum sampling) position for 20 minutes, with lowest range switch depressed.

2.2.2 Zero Adjustment

After the instrument has warmed up, push the zero button on Model 251 or short the input on Model 252 and adjust the zero control until the negative light just goes out.

2.2.3 Calibrate Adjustment

After the instrument has been properly zeroed, push the calibrate button and adjust the calibrate control for a digital display of 9000 on Model 251 or 2700 on Model 252.

2.2.4 Overrange Blanking

When the input voltage exceeds the maximum digital reading, beyond the overrange, the display will blank leaving only the sampling indicator flashing. This occurs above 2999 digits on Model 252, and above 13,999 digits on Model 251.

FIGURE 1

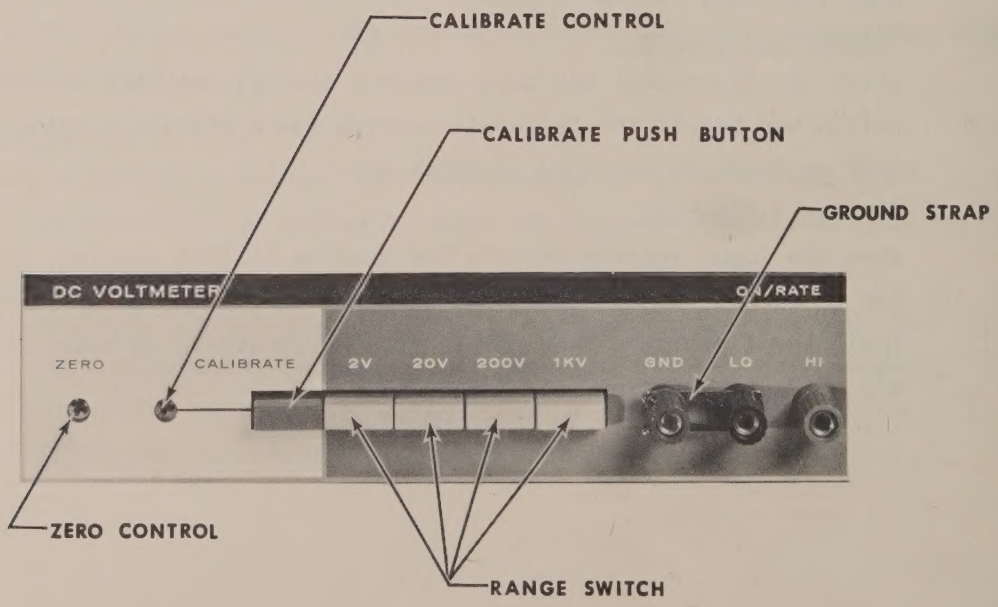


FIGURE 2

2.2.4 Overrange Blanking (Cont'd)

If an extremely large voltage is applied to the input, the digital display may come back on. This is due to a saturation effect of the protective circuit. This reading will be incorrect but will not harm the instrument in any way.

Example: If a 12 volt source is applied to the 2 volt range of a Model 252, the digital display may come back on. The Model 251 is factory checked for blanking up to 40 volts on the 10 volt range and the Model 252 is checked up to 10 volts on the 2 volt range

When the digital display blanks, there will be an output logic to indicate the blanked condition.

2.2.5 Differential DC Voltage Measurement

Signal and case grounds can be separated on the front panel of the plug in. The maximum specified common mode voltage is 500 volt peak.

2.3 Possible Sources of Error

When measuring an unknown voltage, always start at the highest voltage range and go down until the best possible resolution is obtained. If a very high voltage is applied to a low voltage range, the voltmeter may read incorrectly. (See Section 2.2.4)

2.3.1 Ground Loop Precaution

External fields of ground currents of power line frequency, if extremely large, can result in normal or common mode pickup. While AC rejection ratios are high (Section 1.4), the signal and case grounds should be separated and short or twisted input leads used whenever possible.

2.3.2 Loading Error

Loading error is caused by the finite input resistance. If the source resistance is high, this must be taken into account to get the true voltage reading. For example, if the source resistance of a 1 volt power supply is 10K ohms and the voltage is being measured on the 2 volt range of Model 252, then the reading error will be .1% or 1Mv.

2.3.3 Environment

A number of possible sources of error are introduced by severe environments. The 251-1 and 252-1 are designed to eliminate as many of these as possible.

Both temperature and humidity factors have been taken into account. Humidity effects have been reduced by extremely careful treatment of the insulating surfaces.

Extreme caution should be taken to make certain that the range switch is kept absolutely clean.

Corrosive atmospheres, particularly when the humidity is high, can cause large leakage currents. The plug-in module is an exposed board and should be protected from contamination by keeping it in a clean dry place whenever it is not plugged into the main frame.

2.4 Use of a Converter for AC Measurements

An AC to DC converter, such as the DigiTec Series 900, may be used with either the 251-1 or 252-1 Voltmeter module, however, the conversion accuracy and reading time will affect the overall measurement and must not be neglected.

When using the 251-1 or 252-1 for AC measurements, the internal fast-normal jumper must be in the normal position.

The Models 900-1 and 900-2 AC to DC converters are designed to operate with the Models 251-1 and 252-1 Plug-In Modules, respectively.

3. AC INTERFERENCE

3.1 Normal Input

The 251-1 and the 252-1 are specified to have 75Db normal mode rejection of 60Hz interference. This means that the apparent reading error, which may be either plus or minus, will be 1/5600 of the impressed AC value. To illustrate, if we add 5.6 volts P-P of 60Hz AC to $\frac{1}{2}$ volt DC level, we will note an extra error of 1/5600 x (5.6V) added to the 2 volt range. This is an extra .001 volt error. Consequently, the reading could shift by ± 2 digits instead of the usual ± 1 digit. Four out of five readings will be either .502, .501, .499, or .498. So as a result of adding 5.6 volts of 60Hz AC, we have added .001 volt of

3.1 Normal Input (Cont'd)

uncertainty to the final reading, certainly a very small error. However, it is preferable to keep the AC voltages within the limits allowed for 1 digit extra error. If very large AC components are present, an additional low-pass filter may be connected at the input terminals, but loading error must be considered. To connect the instrument for normal operation, see Figure 7.

3.2 Fast Input

When using fast input, the instrument reads the instantaneous value of the input voltage at the instant of comparison. The fast input position bypasses both the active filter and the passive Twin "T" filter; therefore, there is no AC rejection in this position. In the fast mode, only the lowest range (i.e., 10 volt on Model 251-1 or 2 volt on Model 252-1) may be used. The input voltage must not exceed 50 volts. To use the fast input connect both jumpers to Fast (See Figure 7).

3.3 Twin "T" Filter Only

By using the Twin "T" filter only, it is possible to get 40Db of AC attenuation at 60Hz, but no attenuation at other frequencies. To use the Twin "T" filter alone connect Jumper No. 1 to normal and Jumper No. 2 to fast. (See Fig. 7) Do not exceed 50 volts on Model 252-1.

4. CIRCUIT DESCRIPTION (Figures 3 and 4)

The input voltage goes through the notch filter which removes most of the 60Hz noise, and then to the attenuator. From the attenuator the input voltage goes to the low-pass filter, which further reduces any high frequency noise that may be present. From there the now nearly pure DC signal goes to an overvoltage protection circuit, and then to the dual comparator.

At the start of a sampling cycle, the control circuit located in the main frame, resets the BCD counter, which is also located in the main frame, to 0000. The ramp is then initiated. The dual comparator now compares the input voltage to the ramp voltage, thus converting the input voltage into a gate, whose width is proportional to the input

4. CIRCUIT DESCRIPTION (Cont'd)

voltage. The output of the dual comparator drives the Exclusive "OR", which in turn drives a gated frequency divider, thus converting the gate width into a pulse train of constant frequency, but whose pulse count is proportional to the input voltage. This pulse train is then fed into the BCD counter and displayed on the digital readout.

4.1 Notch Filter

The notch filter is a Twin "T" filter designed to have maximum rejection at 60Hz. This filter precedes the input attenuator in the normal mode and is then removed in the fast mode of operation. Jumper No. 1 is used to insert or remove this filter from the circuit. (See Figure 7)

4.2 Input Attenuator

A DC voltage applied to the input terminal is fed to a precision resistive attenuator, where it is divided by decades to 2 volts. In the calibrate mode a precision calibration voltage is used in place of the input voltage. For precise voltage calibration, a potentiometer adjusts for every range except the lowest range. These trimmers should not be adjusted unless a very accurate voltage standard is available. (See Section 5.1)

4.3 Low-Pass Filter

The Low-Pass filter consists of an FET source follower that has AC feedback to provide a cutoff frequency of approximately 10Hz. The rolloff of this filter is approximately 40Db/decade. This filter is located between the attenuator and the dual comparator, and can be by-passed by moving Jumper Number 2 from normal mode to fast mode. (See Figure 7)

4.4 Overload Protection

Overload protection is accomplished by the use of two low leakage, factory selected transistors that are used in the circuit as clipper diodes (D2 and D3). Their function is to limit the voltage to the comparator to 3.6 volts.

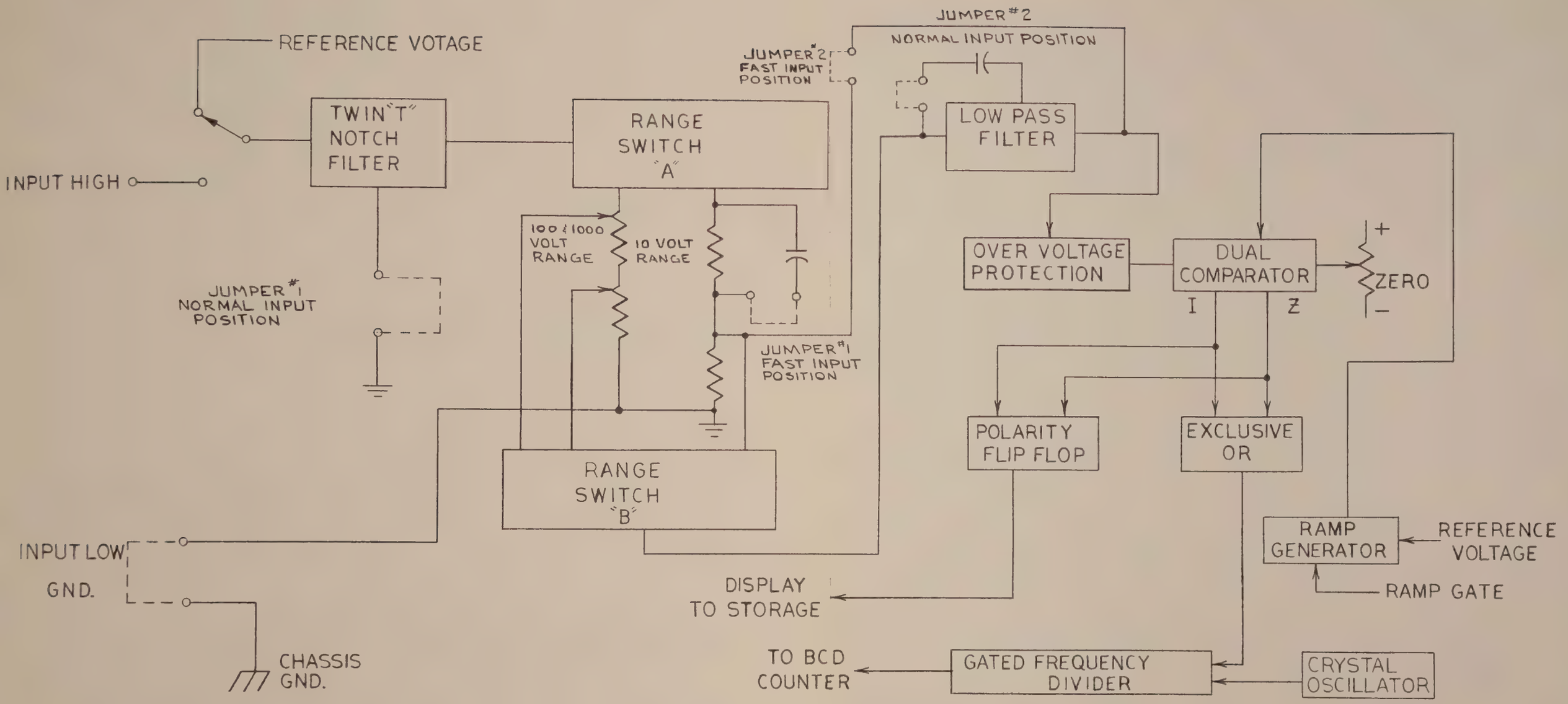

REFERENCE VOTAGE
INPUT HIGH
TWIN "T" NOTCH FILTER
JUMPER #1 NORMAL INPUT POSITION
JUMPER #2 FAST INPUT POSITION
RANGE SWITCH "A"
100 & 1000 VOLT RANGE
10 VOLT RANGE
JUMPER #1 FAST INPUT POSITION
RANGE SWITCH "B"
JUMPER #2 NORMAL INPUT POSITION
LOW PASS FILTER
OVER VOLTAGE PROTECTION
DUAL COMPARATOR
I
Z
+
ZERO
−
POLARITY FLIP FLOP
EXCLUSIVE OR
RAMP GENERATOR
REFERENCE VOLTAGE
RAMP GATE
INPUT LOW
GND.
CHASSIS GND.
DISPLAY TO STORAGE
TO BCD COUNTER
GATED FREQUENCY DIVIDER
CRYSTAL OSCILLATOR

FIGURE 3

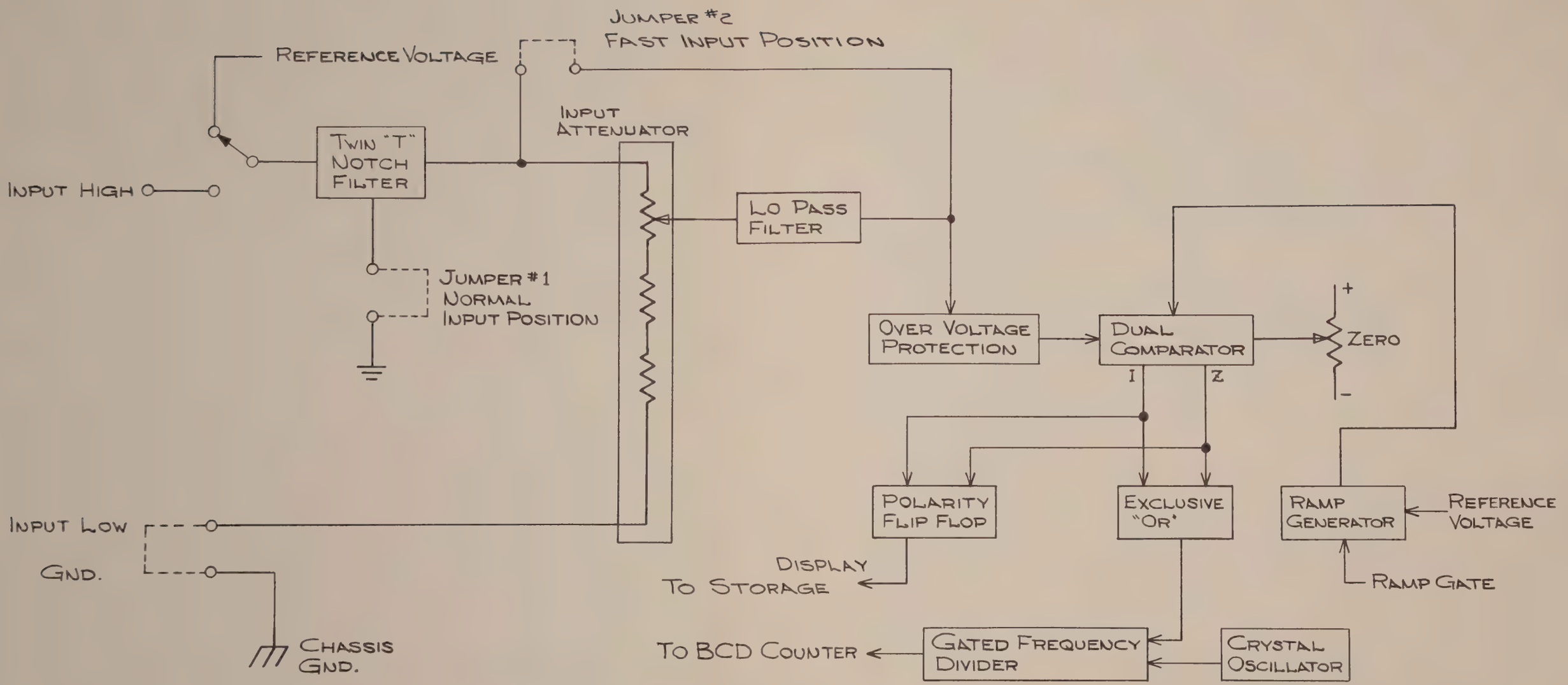

JUMPER #2
FAST INPUT POSITION
REFERENCE VOLTAGE
INPUT ATTENUATOR
TWIN "T" NOTCH FILTER
INPUT HIGH
LO PASS FILTER
JUMPER #1
NORMAL INPUT POSITION
OVER VOLTAGE PROTECTION
DUAL COMPARATOR
+
ZERO
-
1
2
POLARITY FLIP FLOP
EXCLUSIVE "OR"
RAMP GENERATOR
REFERENCE VOLTAGE
RAMP GATE
DISPLAY TO STORAGE
INPUT LOW
GND.
CHASSIS GND.
TO BCD COUNTER
GATED FREQUENCY DIVIDER
CRYSTAL OSCILLATOR

FIGURE 4

4.4 Overload Protection (Cont'd)

In addition to the clipper diodes, Model 251-1 also contains a neon lamp. This lamp is used to attenuate extremely high overloads, on the 10 volt range, to a safe level.

4.5 Ramp Generator

The ramp generator, which is potted for temperature stability, consists of a high gain operational amplifier with capacitive feedback. By using capacitive negative feedback, the amplifier becomes an integrator. To assure that the ramp voltage is perfectly linear, positive feedback is applied by means of a linearity control. This control will be discussed in more detail in the maintenance section (Section 5.2.1).

4.6 Dual Comparator

The dual comparator, which is also potted for temperature stability, serves as a voltage-to-time converter by comparing the input voltage and an adjustable "zero" voltage to the ramp voltage, from the ramp generator. The minimum ramp swing is from approximately +3.0 volts to -4.2 volts; thus, sweeping the entire range of possible input voltages. When voltage coincidence between the ramp and the input voltage is reached, an abrupt logic change occurs at the "I" output of the comparator. An identical logic change at the "Z" output of the comparator occurs upon coincidence of the ramp and the "zero" voltage.

4.7 Exclusive "OR"

The Exclusive "OR" gate detects when the "I" and "Z" comparator outputs are different, thus generating a time interval. Since both the input voltage and the "zero" voltage were compared to a ramp of constant slope with respect to time, the time interval generated by the Exclusive "OR" gate is a linear function of the voltage difference between the input and the zero side of the comparator. With the input at zero volts, the zero adjustment may be adjusted so that the Exclusive "OR" output has a zero time interval, thus effectively eliminating any internal circuit offsets that the comparator might present.

4.8 Crystal Oscillator

The oscillator section consists of a stable, highly accurate, Colpitts crystal oscillator, with a frequency of 5MHz and a total overall accuracy of 0.1%. In order to make the oscillator stable, it is allowed to run free at all times.

4.9 Gated Frequency Divider

The first of three J-K flip flops is controlled by the Exclusive "Or" circuit and acts as a gate for the count output. The count is then divided by 8, with three flip flops, in order to produce a resolution equal to $\pm 1/8$ of the least significant digit of the digital display.

4.10 Polarity Flip Flop

The polarity of the input voltage is detected by the polarity flip flop. It detects whether the signal side of the comparator is "fired" before or after the ramp crossed the zero reference line. Thus, if the zero side of the comparator "fired" first, a negative sign is generated which is stored and displayed along with the BCD count.

5. MAINTENANCE

5.1 Necessary Maintenance Equipment

1. Stable precision voltage source of .01% accuracy or better, such as a Hewlett-Packard 704B Standard/Differential Voltmeter.
2. Oscilloscope capable of measuring 5MHz or higher such as a Tektronix 535A.

5.2 Periodic Test (1000 hours or 6 months)

5.2.1 Symmetry

1. Let the instrument warm up for 20 minutes.
2. Set the sample rate control to the fully clockwise position (maximum sampling rate).
3. Very carefully zero the instrument (section 2.2.2).
4. Apply a positive, stable voltage to the input terminals. (Voltage setting of 9.00 volts on Model 251-1 and 2.900 volts on Model 252-1 plug-in).
5. Depress the lowest range button; i.e., 2 volts or 10 volts.
6. Note the digital display reading. The digital display may not

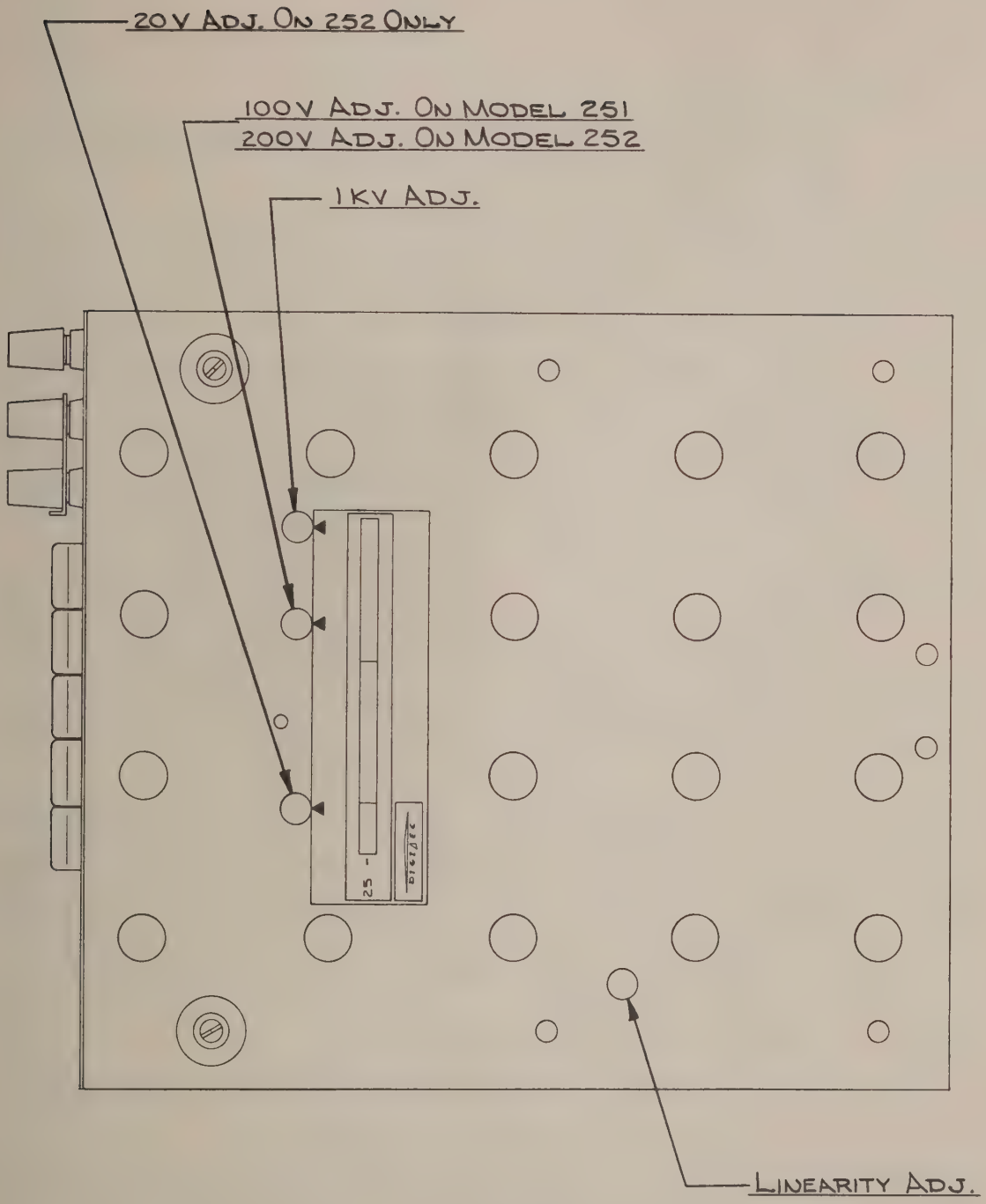

20V ADJ. ON 252 ONLY
100V ADJ. ON MODEL 251
200V ADJ. ON MODEL 252
1KV ADJ.
LINEARITY ADJ.

FIGURE 5

5.2.1 Symmetry (Cont'd)

read the same as the input voltage if the instrument is out of calibration.

7. Reverse the polarity of the input voltage.

8. Note the digital display reading again. If both readings are the same, go to Step 5.2.2. If the negative reading was higher than the positive reading, turn the linearity control clockwise (the linearity control is located on the bottom of the plug-in module, See Figure 7). If the positive reading was higher than the negative reading, turn the linearity control counterclockwise. Repeat Steps 4, 5, 6, and 7 until both the positive and negative voltage readings are the same, ±1 digit, but not necessarily the same as the input voltage.

5.2.2 Calibration

1. Push the calibrate button and adjust the calibrate trimmer to "9000" on Model 251-1 or "2700" on Model 252-1 voltmeter plug-in.

2. Connect a stable, precise voltage source with accuracy of 0.01% or better to the input of the voltmeter. (Section 5.1)

251-1 Model Only

3A. Push the 10 volt range button. Set the power source to 9.000 volts. The digital display should read 9.000 volts. If it does not, the internal reference may be incorrect. There are two ways to adjust the internal reference voltmeter:

1. By using a precision voltmeter (see the 251-252 Main Frame Instruction Manual)

2. By using a precision voltage source:

a. To do this, push the zero button and very carefully adjust the zero trimmer to 0000. (Section 2.2.2)

b. Connect a precision 9.000 volt source to the input terminals

c. Push the 10 volt range button and adjust the calibrate trimmer on the front panel for 9.000 on the digital display.

d. Push the calibrate button and adjust the internal reference trimmer (See photo in the Main Frame Instruction Manual) for 9000 on the digital display.

5.2.2 Calibration (Cont'd)

4. a. Push the 100 volt range pushbutton.
   b. Change the voltage source to 120.00 volts.
   c. Adjust the 100 volt attenuator on the bottom of the plug-in module to obtain a reading on the digital display of 120.00 volts. (Figure 7)

5 a. Push the 1000 volt range pushbutton.
   b. Change the voltage source to 1000.00 volts.
   c. Adjust the 1000 volt attenuator on the bottom of the plug in to obtain a reading on the display of 1000.00 volts. (See Figure 5)

3B. 252-1 Model Only

Push the 2 volt range button. Set the power source to 2.700 volts. The digital display should read 2.700 volts. If it does not, the internal reference may be incorrect. There are two ways to adjust the reference voltage:

1. By using a precision voltmeter (See 251-252 Main Frame Instruction Manual)
2. By using a precision voltage source:
   a. Push the 2 volt range button, short the input, and very carefully adjust the front panel zero trimmer for 0000. (Section 2.4)
   b. Connect a precision 2.700 volt source to the input terminals.
   c. Push the 2 volt range button and adjust the calibrate trimmer on the front panel for 2.700 on the digital display.
   d. Push the calibrate button and adjust the internal reference trimmer (See photo in the Main Frame Instruction Manual) for 2700 on the digital display.

5.2.2 Calibration (Cont'd)

3. a. Push the 20 volt range pushbutton.
   b. Change the voltage source to 25.00 volts.
   c. Adjust the 20-volt attenuator on the bottom of the plug-in module to obtain a reading on the digital display of 25.00 volts.(See Figure 7)
4. a. Push the 200 volt range pushbutton.
   b. Change the voltage source to 250.0 volts.
   c. Adjust the 200-volt attenuator on the bottom of the plug-in module to obtain a reading on the digital display of 250.0 volts.(Figure 7)
5. a. Push the 1KV range pushbutton.
   b. Change the voltage source to 1000.0 volts.
   c. Adjust the 1000-volt attenuator on the bottom of the plug-in module to obtain a reading on the display of 1000 volts. (See Figure 5)

6. SERVICE AND TROUBLESHOOTING

6.1 Troubleshooting Hints

1. Scan the boards for broken wires, or charred or otherwise damaged components.
2. Determine the presence of a proper ramp.
3. Check the comparator.
4. Check the output of the Exclusive "OR" circuit.
5. Check for proper operation of the oscillator.
6. Check the frequency divider circuit.
7. Check the polarity flip flop.

6.2 Ramp Generator

The ramp generator has an extremely linear negative going slope. The linearity and noise of the positive going slope is of no consequence. The negative slope should not have more than 1MV of noise. If no ramp is present, look for broken wires going to the calibrate potentiometer and other associated components (See Figure 12.).

6.3 Comparator

The comparator has two outputs (Points C and D). The width of the output is proportional to the input voltage. In order to check the output wave shapes, a stable, but not necessarily accurate or precise, input voltage must be applied to the input terminals. When testing the 251-1 plug-in, set the input voltage first to plus, then minus 10 volts with the range switch on the 10 volt range, and on the 252-1 plug in, set the input voltage first to plus, then minus 2 volts with the range switch on the 2 volt range. (See Figure 12)

6.4 Exclusive "OR" Gate

To check the Exclusive "OR" gate apply the same voltages that were used in checking out the dual comparator. The waveshape seen in Figure 12 will be found at Test Point B.

6.5 Oscillator

The oscillator is free running and can be easily checked at Point G. The scope for this test must be capable of measuring 5MHz.

6.6 Frequency Divider

The divider output at Test Point E is being gated on and off at the sampling rate frequency. The important part of this waveshape is the oscillator's frequency. If the frequency is other than 625KHz, then one or more of the J-K flip flops may be defective. (Figure 12)

6.7 Polarity Flip Flop

The polarity flip flop is the first half of IC2. The output at Test Point F will be a DC level of +1.6 volts when the input voltage is positive, but will be a pulse when the input voltage is negative. (See Figure 12)

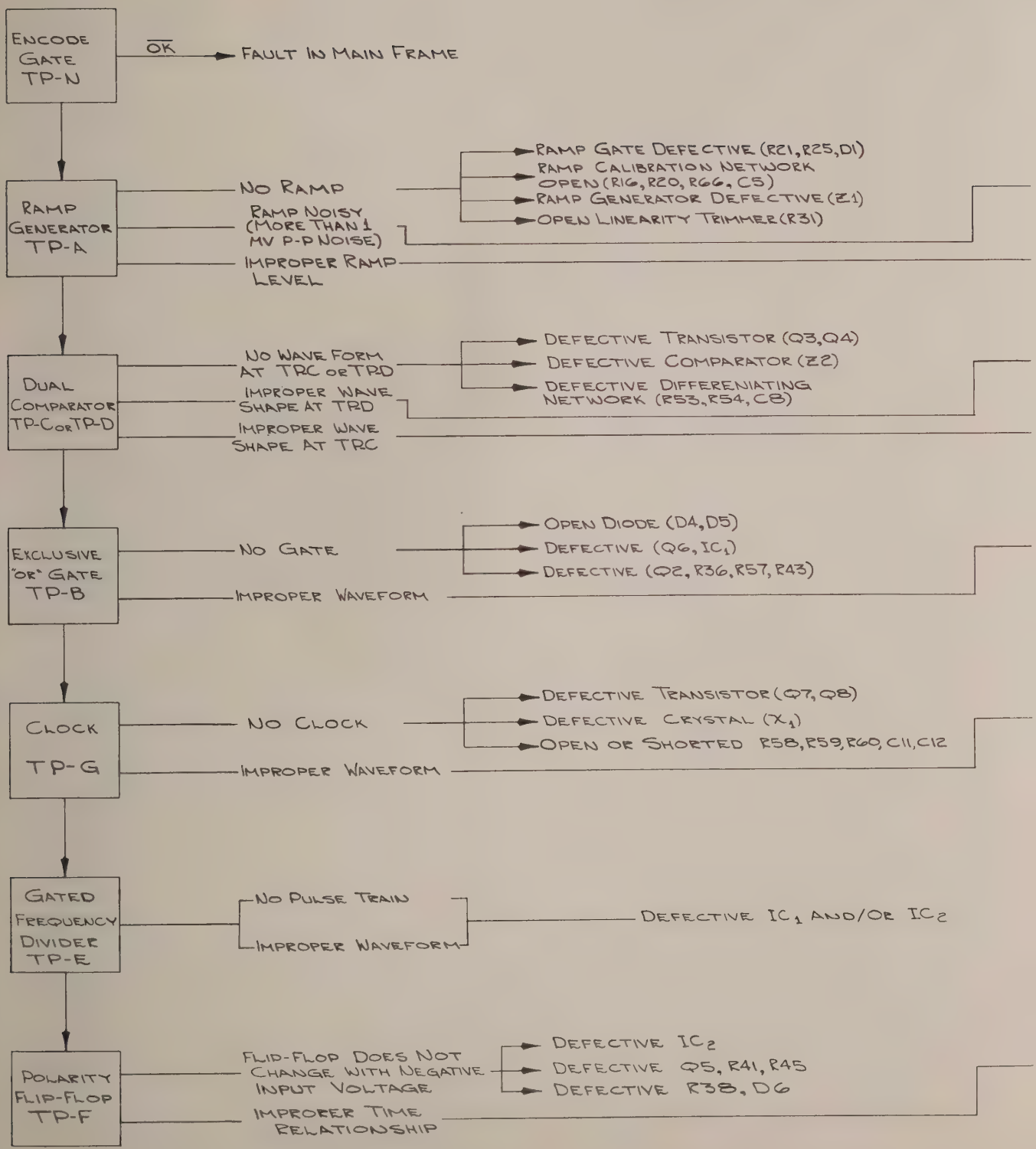
7. TROUBLESHOOTING CHART

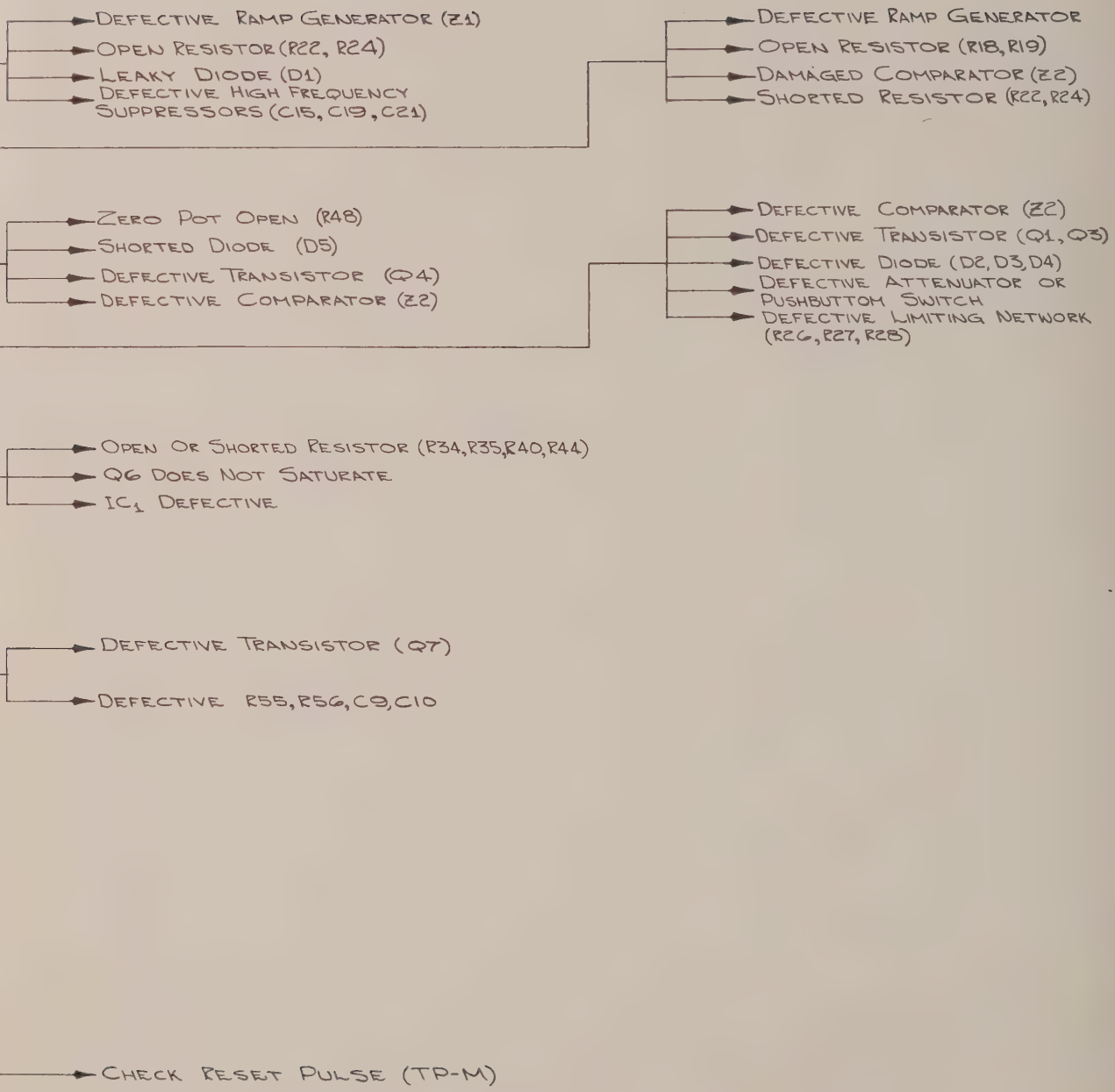
Symptoms	Possible Cause	Section
Readout of voltmeter will not differ from 0000. Zero control has no effect.	Defective IC, oscillator	6.4,6.5
Voltmeter seems to operate properly, but will not zero	Defective FET (Q1) or clipper diodes D2 or D3	4.3,4.4
Polarity incorrect	Check polarity circuit Q5, IC2, D6	6.7
Linearity will not adjust properly	Check FET (Q1), ramp generator, linearity potentiometer	4.3,6.2
Improper blanking (comes back on too soon)	Check Clipper Diodes D2 and D3	4.4, 2.3.4
Attenuator controls will not adjust properly	Defective attenuator resistor or potentiometer, leaky switch	4.2
Readings too high on 1000 volt range only	Leaky pushbutton switch (replace switch)	4.2
Poor AC rejection	Check FET (Q1)	4.3

TROUBLESHOOTING FLOW CHART

The 251-1 and 252-1 plug-in modules may be methodically analyzed to pinpoint faults. The proper waveforms for use with the troubleshooting chart are shown in the timing diagram. The oscilloscope should be externally triggered by the positive going edge of the encode gate. (Test Point 7)(See Figure 12)

TROUBLE SHOOTING FLOW CHART


ENCODE GATE TP-N
$\overline{OK}$
FAULT IN MAIN FRAME
RAMP GENERATOR TP-A
NO RAMP
RAMP NOISY (MORE THAN 1 MV P-P NOISE)
IMPROPER RAMP LEVEL
RAMP GATE DEFECTIVE (R21, R25, D1)
RAMP CALIBRATION NETWORK OPEN (R16, R20, R66, C5)
RAMP GENERATOR DEFECTIVE (Z1)
OPEN LINEARITY TRIMMER (R31)
DUAL COMPARATOR TP-C OR TP-D
NO WAVE FORM AT TRC OR TRD
IMPROPER WAVE SHAPE AT TRD
IMPROPER WAVE SHAPE AT TRC
DEFECTIVE TRANSISTOR (Q3, Q4)
DEFECTIVE COMPARATOR (Z2)
DEFECTIVE DIFFERENIATING NETWORK (R53, R54, C8)
EXCLUSIVE "OR" GATE TP-B
NO GATE
IMPROPER WAVEFORM
OPEN DIODE (D4, D5)
DEFECTIVE (Q6, IC1)
DEFECTIVE (Q2, R36, R57, R43)
CLOCK TP-G
NO CLOCK
IMPROPER WAVEFORM
DEFECTIVE TRANSISTOR (Q7, Q8)
DEFECTIVE CRYSTAL (X1)
OPEN OR SHORTED R58, R59, R60, C11, C12
GATED FREQUENCY DIVIDER TP-E
NO PULSE TRAIN
IMPROPER WAVEFORM
DEFECTIVE IC1 AND/OR IC2
POLARITY FLIP-FLOP TP-F
FLIP-FLOP DOES NOT CHANGE WITH NEGATIVE INPUT VOLTAGE
IMPROPER TIME RELATIONSHIP
DEFECTIVE IC2
DEFECTIVE Q5, R41, R45
DEFECTIVE R38, D6


DEFECTIVE RAMP GENERATOR (Z1)
OPEN RESISTOR (R22, R24)
LEAKY DIODE (D1)
DEFECTIVE HIGH FREQUENCY SUPPRESSORS (C15, C19, C21)
DEFECTIVE RAMP GENERATOR
OPEN RESISTOR (R18, R19)
DAMAGED COMPARATOR (Z2)
SHORTED RESISTOR (R22, R24)
ZERO POT OPEN (R48)
SHORTED DIODE (D5)
DEFECTIVE TRANSISTOR (Q4)
DEFECTIVE COMPARATOR (Z2)
DEFECTIVE COMPARATOR (Z2)
DEFECTIVE TRANSISTOR (Q1, Q3)
DEFECTIVE DIODE (D2, D3, D4)
DEFECTIVE ATTENUATOR OR PUSHBUTTOM SWITCH
DEFECTIVE LIMITING NETWORK (R26, R27, R28)
OPEN OR SHORTED RESISTOR (R34, R35, R40, R44)
Q6 DOES NOT SATURATE
IC1 DEFECTIVE
DEFECTIVE TRANSISTOR (Q7)
DEFECTIVE R55, R56, C9, C10
CHECK RESET PULSE (TP-M)

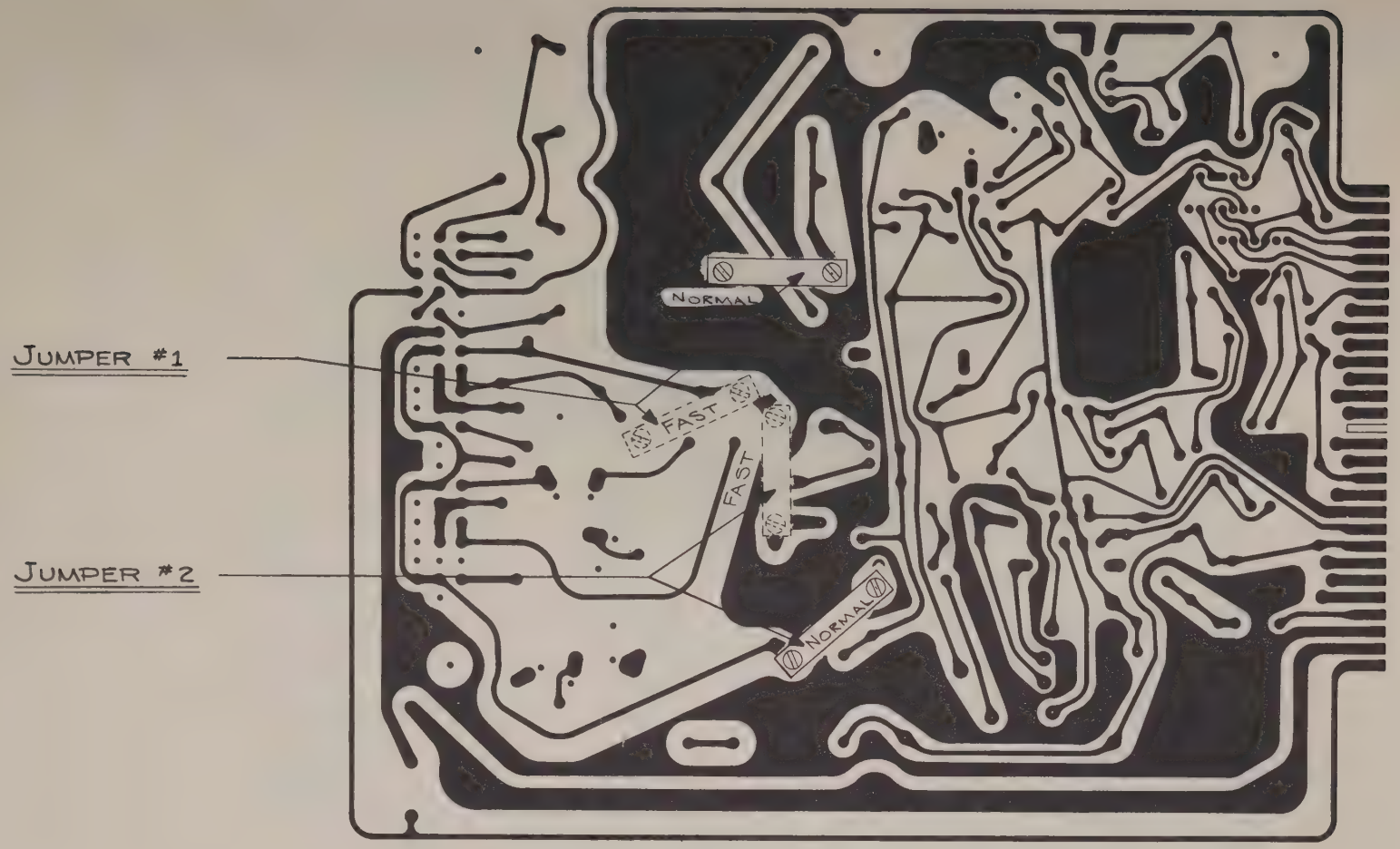


FIGURE 7 VIEW 1

(251)

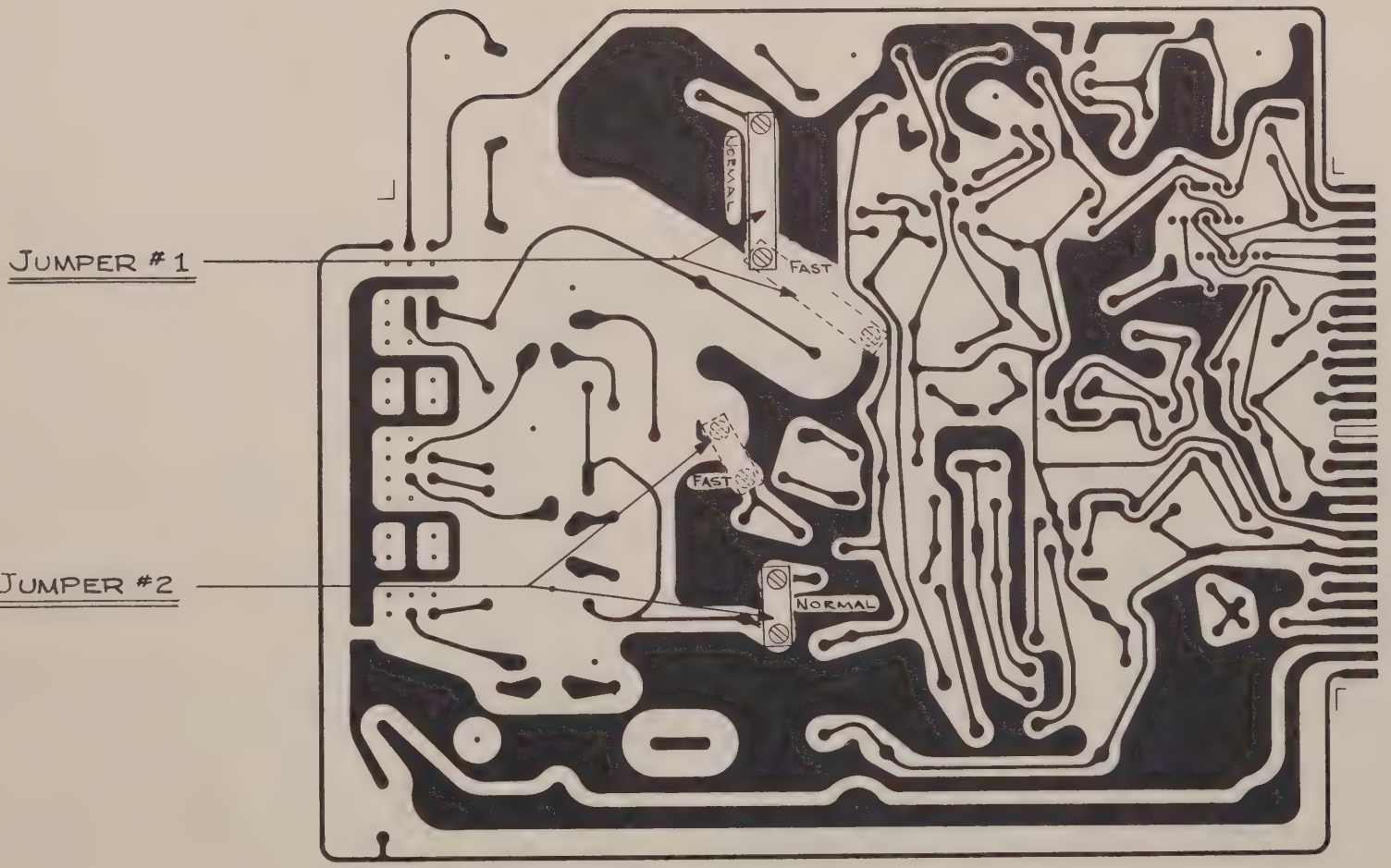
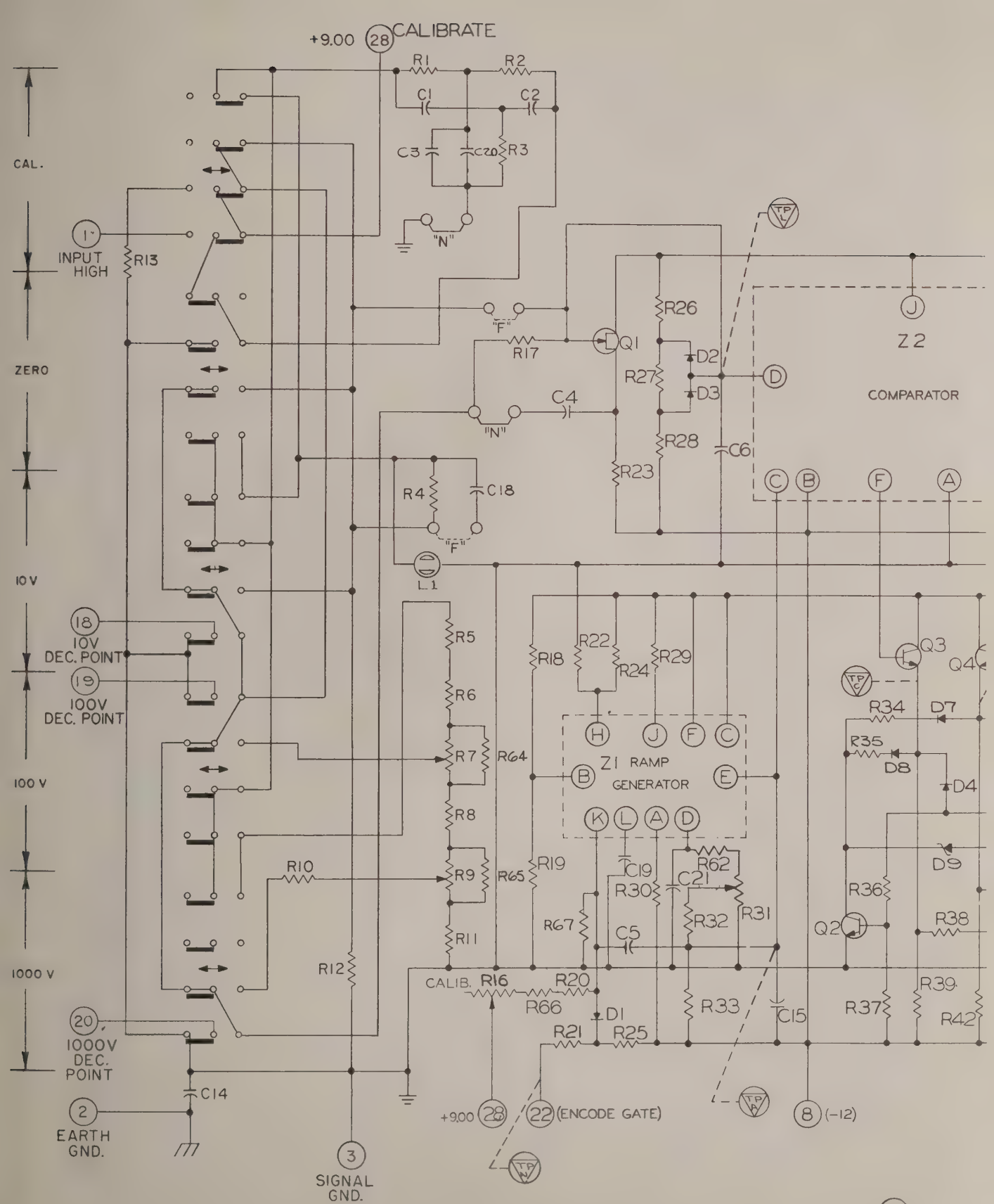


FIGURE 7 VIEW 2

(252)



INDICAT
SEE IN

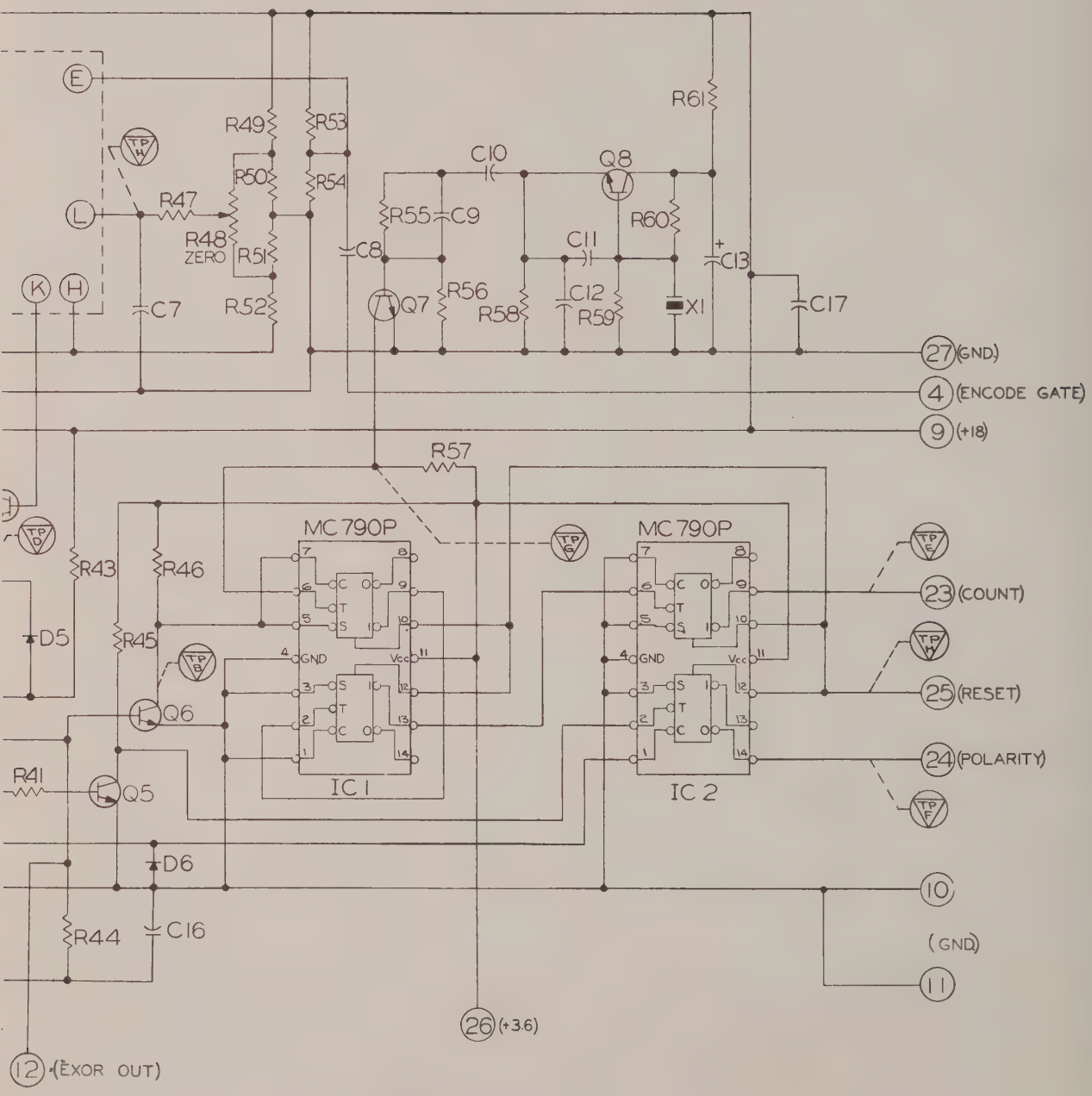


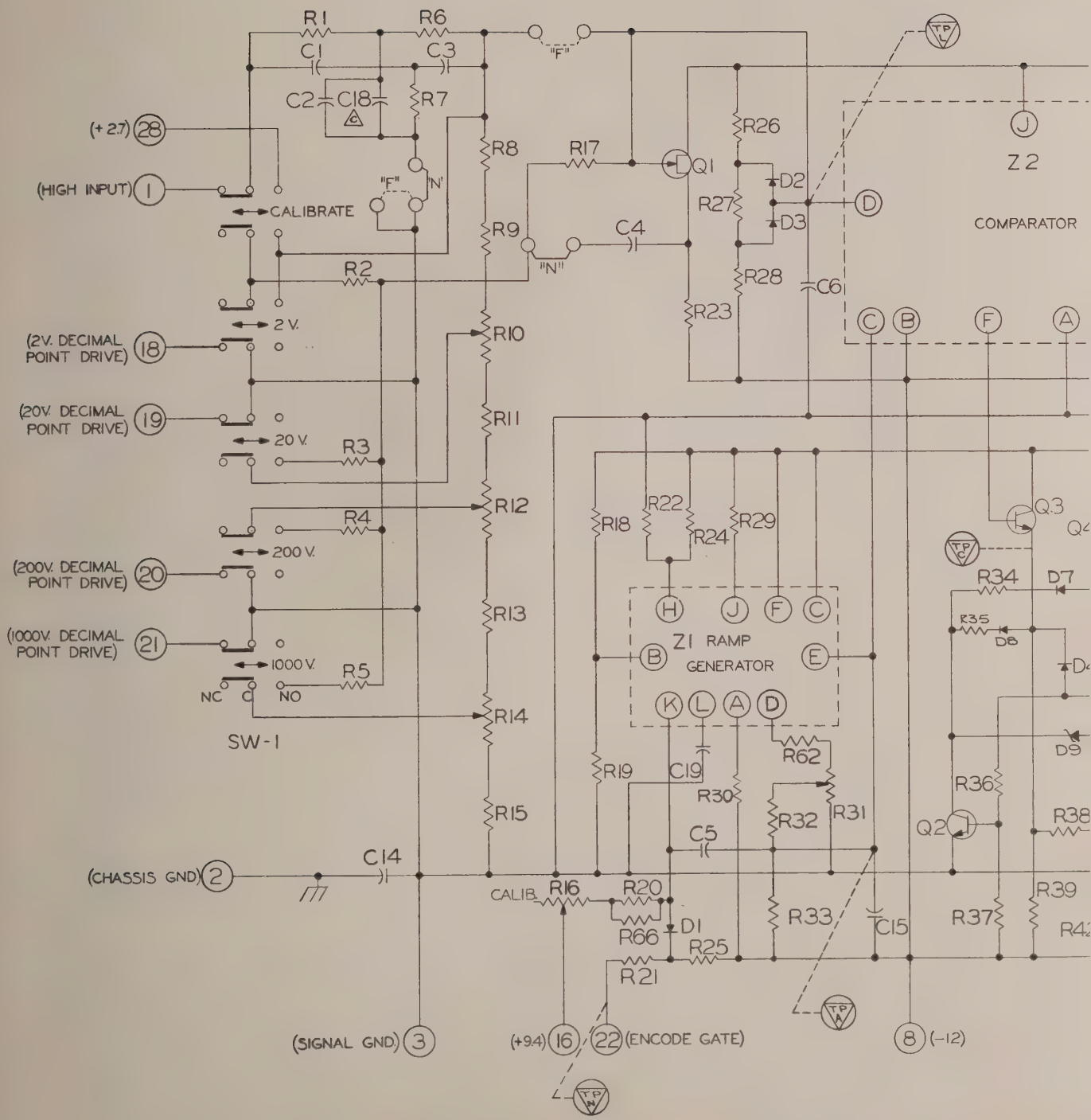
FIGURE 8

ION OF TEST POINTS:
STRUCTION MANUAL.

Parts List for 251-1

SYMBOL	DESCRIPTION	STOCK NUMBER
C1,2,3,20	Capacitor, .05mfd, 1600VDC,10%	56-10212F503J16
C4,6,7	Capacitor, .22mfd, 100VDC,10%,Mylar	56-10206BYB224J2
C5	Capacitor, .47mfd, 100VDC,2%, Polystryrene	56-10208EY474EL1
C8, 18	Capacitor, .05mfd, 200VDC,20%,Mylar	56-10205BYB503J2
C9	Capacitor, 1500pf,1000VDC,20%, Ceramic	56-10215A152JE10
C10,15	Capacitor, .01mfd,50VDC,20%,Mylar	56-10205AYA103J4
C11	Capacitor, 1300pf,500VDC,10%,Mica	56-10210B132JP5
C12, 19	Capacitor, 75pf,500VDC,5%,Mica	56-10210A750JP5
C13	Capacitor, 10mfd,25VDC, Electrolytic	56-10201AT106N30
C14	Capacitor, .05mfd,600VDC,20%,Mylar	56-10205CYC503J6
C16,17	Capacitor, 1mfd,100VDC,10%,Mylar	56-10206CYC105J1
C21	Capacitor, 390pf,500VDC, Mylar	56-10210A391HK5
R1,2	Resistor, 49.9K ohm,1W,1%	55-10111EL49R9K
R3	Resistor, 24.9K ohm,1W,1%	55-10111EL24R9K
R4	Resistor, 700.2K ohm,1W,1%	55-10111BJ700R2K
R5,6	Resistor, 4.847Meg ohm,2W,.1%	55-10113BJ4R8476M
R7	Trimmer, 3K ohm,2W,20%	55-10151K3K
R8	Resistor, 178.88K ohm,1W,.1%	55-10111BJ178R88K
R9	Trimmer, 300 ohm,2W,20%	55-10151K300
R10	Resistor, 180K ohm,½W,5%	55-10105H180K
R11	Resistor, 19.9K ohm,1W,.1%	55-10111BJ19R9K
R12	Resistor, 200K ohm,1W,.1%	55-10111BJ200K
R13	Resistor, 1Meg ohm,1W,1%	55-10111EL1M
R16	Trimmer, 10K ohm,2W,20%,(Not on PC Board)	55-10154K10K
R17,47	Resistor, 220K ohm,½W,5%	55-10102H220K
R18,24	Resistor, 3.9K ohm,½W,5%	55-10105H3R9K
R19,23,41,56	Resistor, 10K ohm,½W,5%	55-10105H10K
R20	Resistor, 148.2K ohm,10W,.1%	55-7426
R21	Resistor, 1.5K ohm,½W,5%	55-10105H1R5K
R22	Resistor, 5.6K ohm,½W,5%	55-10105H5R6K
R25,34,35	Resistor, 12K ohm,½W,5%	55-10105H12K
R26	Resistor, 1.47K ohm,1W,1%	55-10111EL1R47K
R27	Resistor, 549 ohm,1W,1%	55-10111EL549
R28	Resistor, 1Kohm,1W,1%	55-10111EL1K
R29,30	Resistor, 56K ohm,½W,5%	55-10102H56K
R31	Trimmer, 800 ohm,2W,20%	55-10151K800
R32	Resistor, 82K ohm,½W,5%	55-10105H82K
R33, 43,55	Resistor, 4.7K ohm,½W,5%	55-10105H4R7K
R36,45,58	Resistor, 1K ohm,½W,5%	55-10105H1K
R37	Resistor, 22K ohm,½W,5%	55-10105H22K
R38,54	Resistor, 15K ohm,½W,5%	55-10105H15K
R39,42	Resistor, 3.3K ohm,½W,5%	55-10105H3R3K
R44	Resistor, 68K ohm,½W,5%	55-10105H68K
R46	Resistor, 1.8K ohm,½W,5%	55-10102H1R8K
R48	Trimmer, 800 ohm,2W,10% (Not on PC Board)	55-10154K800

SYMBOL	DESCRIPTION	STOCK NUMBER
R49	Resistor, 499K ohm, 1W, 1%	55-10111EL499K
R50,51	Resistor, 130 ohm, 1W, 5%, Wire	55-10121DD130
R52	Resistor, 316K ohm, 1W, 1%	55-10111EL315K
R53	Resistor, 2.7K ohm, ½W, 10%	55-10102J2R7K
R57	Resistor, 680 ohm, ½W, 5%	55-10102H680
R59	Resistor, 680K ohm, ½W, 5%	55-10102H680K
R60	Resistor, 560K ohm, ½W, 10%	55-10102J560K
R61	Resistor, 68 ohm, ½W, 5%	55-10105E68
R62	Resistor, 150K ohm, ½W, 1%	55-10102H150K
R64	Resistor, 9310 ohm, 1W, 1%	55-10111EL9310
R65	Resistor, 976 ohm, 1W, 1%	55-10111EL976
R66	Factory Selected	
D1,2,3	Diode, Clipper	40-7199
D4,5,6,7,8	Diode, Signal	FDH-600
D9	Diode, Zener 6.5V	40-SZ6R5
Q1	F1621 Transistor, Field Effect	40-1621
Q2,6,	2N2921 Transistor, Signal	40-4233-1
Q3,4	2N2925 Transistor, Signal	40-4233-5
Q5,7,8	2N2924 Transistor, Signal	40-4233-4
IC1,2	MC790P, Dual J-K Flip Flop	40-7485
L1	Lamp, Neon	52-7544
X1	5.000MHz Crystal	40-7451
Z1	Ramp Generator Module	4-7040
Z2	Comparator Module	4-7041
SW1	Switch, Pushbutton, Range	43-6954
BD1	Circuit Board	5-7183


R1
R6
C1
C3
C2
C18
R7
"F"
(+27) 28
(HIGH INPUT) 1
CALIBRATE
"F"
"N"
R8
R17
R9
C4
"N"
R2
R26
Q1
D2
R27
D3
R28
C6
R23
J
Z2
COMPARATOR
C
B
F
A
D
2 V.
(2V. DECIMAL POINT DRIVE) 18
R10
(20V. DECIMAL POINT DRIVE) 19
R11
20 V.
R3
R4
200 V.
(200V. DECIMAL POINT DRIVE) 20
R12
R18
R22
R24
R29
Q3
Q4
TP C
R34
D7
(1000V. DECIMAL POINT DRIVE) 21
R13
H
J
F
C
Z1 RAMP GENERATOR
B
E
R35
D6
1000 V.
R5
NC
C
NO
K
L
A
D
R62
D9
SW-1
R14
R19
C19
R30
R36
R15
R32
R31
Q2
R38
C5
C14
(CHASSIS GND) 2
CALIB
R16
R20
R39
R33
C15
R37
R66
D1
R25
R21
TP A
(SIGNAL GND) 3
(+9.4) 16
22 (ENCODE GATE)
8 (-12)
TP N
INDICATION
SEE INSTRU

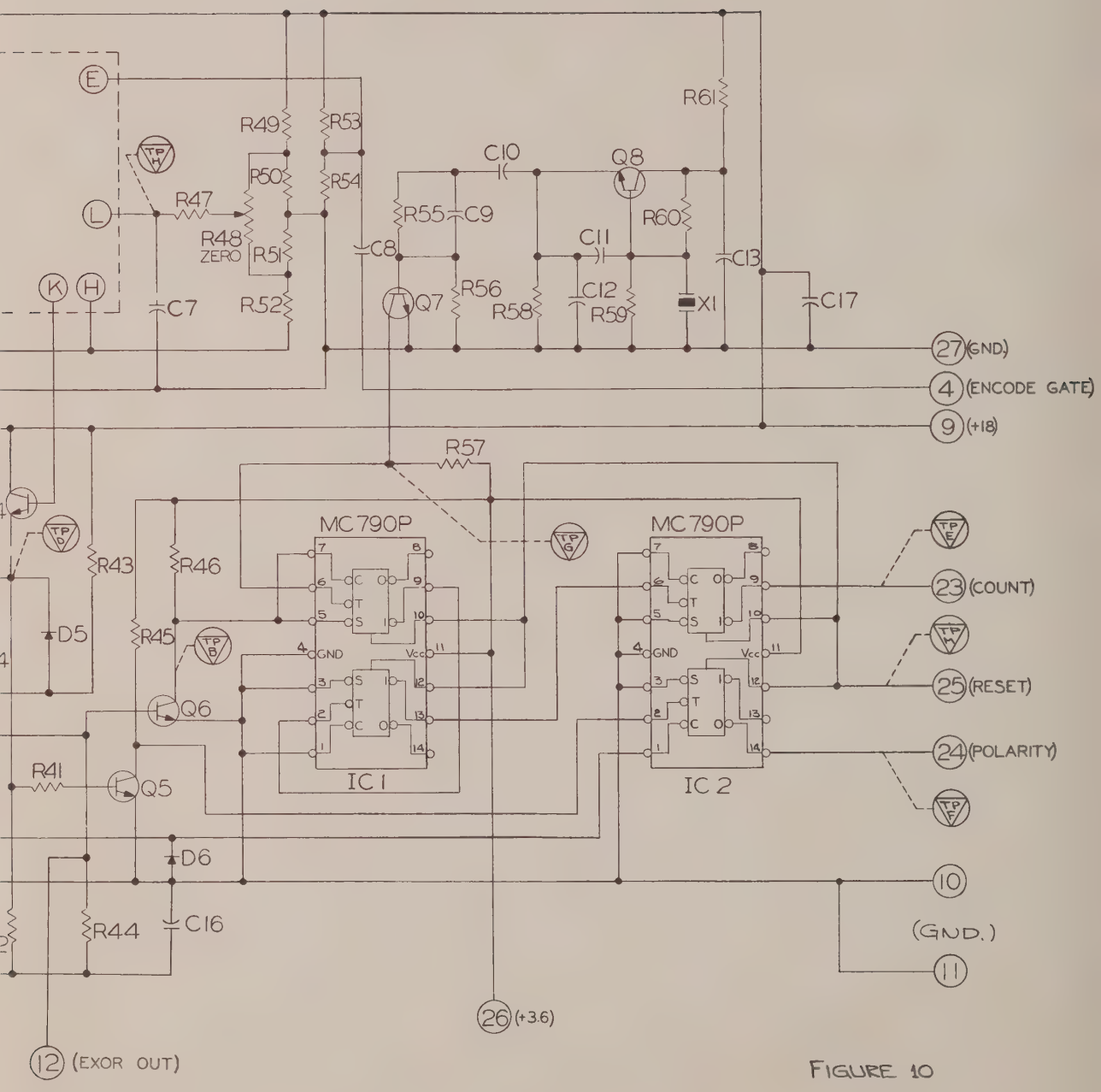


FIGURE 10

OF TEST POINTS:
CTION MANUAL.

Parts List for 252-1

SYMBOL	DESCRIPTION	STOCK NUMBER
C1,2,3,18	Capacitor, .05mfd,1600VDC,10%	56-1021F503J16
C4,14	Capacitor, .05mfd,600VDC,20%,Mylar	56-10205CYC503J6
C5	Capacitor, .47mfd,200VDC,2%,Polycarbonate	56-MLC474H2AT1
C6,7,8	Capacitor, .05mfd,200VDC,20%,Mylar	56-10105BYB503J2
C9	Capacitor, 1500pf,1000VDC,20%,Ceramic	56-10215A152JE10
C10,15	Capacitor, .01mfd,50VDC,20%, Mylar	56-10205AYA103J4
C11	Capacitor, 1300pf,500VDC,10%,Mica	56-10210B132JP5
C12, 19	Capacitor, 75pf,500VDC,5%, Mica	56-10210A750JP5
C13	Capacitor, 10mfd,25VDC,Electrolytic	56-10201AT106N30
C16,17	Capacitor, 1mfd,100VDC,10%, Mylar	56-10206CYC105J1
R1,6	Resistor, 49.9K ohm,1W,1%	55-10111EL49R9K
R2,4	Resistor, 910K ohm,½W,10%	55-10102J910K
R3	Resistor, 100K ohm,½W,5%	55-10105H100K
R5	Resistor, 1Meg ohm,½W,10%	55-10102J1M
R7	Resistor, 24.9K ohm,1W,1%	55-10111EL24R9K
R8,9	Resistor, 4.497Meg ohm,2W,.1%	55-101138J4R497M
R10	Trimmer, 10K ohm,2W,20%	55-10156K10K
R11	Resistor, 893.5K ohm,1W,.1%	55-10111BJ893R5K
R12	Trimmer, 3K ohm,2W,20%	55-10151K3K
R13	Resistor, 88.35K ohm,1W,.5%	55-10111DJ88R35K
R14	Trimmer, 300 ohm,2W,20%	55-10151K300
R15	Resistor, 9850 ohm,1W,1%	55-10111EJ9850
R16	Trimmer, 10K,2W,20%	55-10154K10K
R17	Resistor, 1Meg ohm,1W,1%	55-10111EL1M
R18,24	Resistor, 3.9K ohm,½W,5%	55-10105H3R9K
R19,23,41, 56,21	Resistor,10K ohm,½W,5%	55-10105H10K
R20	Resistor, 33K ohm,2W,.1%	55-10122BD33K
R22	Resistor, 5.6K ohm,½W,5%	55-10105H5R6K
R25,38,54	Resistor, 15K ohm,½W,5%	55-10105H15K
R26	Resistor, 1.47K ohm,1W,1%	55-10111EL1R47K
R27	Resistor, 604 ohm,1W,1%	55-10111EL604
R28	Resistor, 1K ohm,1W,1%	55-10111EL1K
R29	Resistor, 56K ohm,½W,5%	55-10102H56K
R31	Trimmer, 800 ohm,2W,20%	55-10151K800
R32	Resistor, 82K ohm,½W,5%	55-10105H82K
R33, 43,55	Resistor, 4.7K ohm,½W,5%	55-10105H4R7K
R34,35	Resistor, 12K ohm,½W,5%	55-10102H12K
R36,43,58	Resistor, 1K ohm,½W,5%	55-10105H1K
R37	Resistor, 22K ohm,½W,5%	55-10105H22K
R39,42	Resistor, 3.3K ohm,½W,5%	55-10105H3R3K
R44	Resistor, 68K ohm,½W,5%	55-10105H68K
R46	Resistor, 1.8K ohm,½W,5%	55-10102H1R8K
R48	Trimmer, 800 ohm,2W,20%	55-10154K800
R49	Resistor, 499K ohm,1W,1%	55-10111EL499K

SYMBOL	DESCRIPTION	STOCK NUMBER
R50,51	Resistor, 550 ohm,1W,.5%,Wire	55-10121DD550
R52	Resistor, 316K ohm,1W,1%	55-10111EL316K
R53	Resistor, 2.7K ohm,½W,10%	55-10102J2R7K
R57	Resistor, 680 ohm,½W,5%	55-10102H680
R59	Resistor, 680K ohm,½W,5%	55-10102H680K
R60	Resistor, 560K ohm,½W,10%	55-10102J560K
R61	Resistor, 68 ohm,½W,5%	55-10105H68
R66	Factory Selected	
D1,4,5,6,7,8	Diode Signal	FDH-600
D2,3	Diode, Clipper	40-7199
D9	Diode, Zener, 6.5V	40-SZ6.5
Q1	F1621 Transistor, Field Effect	40-F1621
Q2,6	2N2921 Transistor, Signal	40-4233-1
Q3,4	2N2925 Transistor, Signal	40-4233-5
Q5,7,8	2N2924 Transistor, Signal	40-4233-4
IC1, 2	MC790P, Dual J-K Flip Flop	40-7485
X1	5.000MHz Crystal	40-7451
Z1	Comparator Module	4-7041
Z2	Ramp Generator Module	4-7040
SW1	Switch, Pushbutton, Range	43-6954
BD1	Circuit Board	5-7020

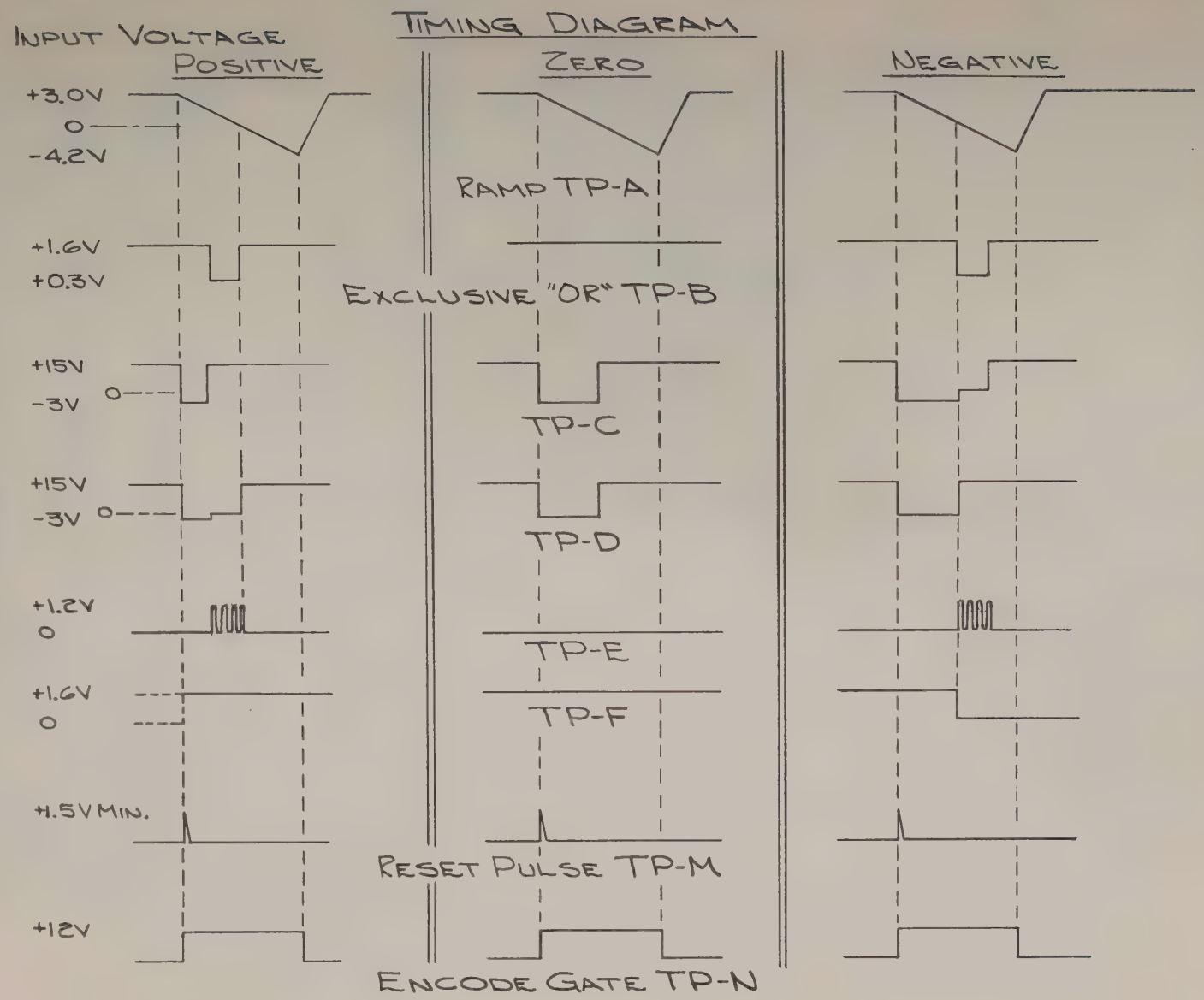

TIMING DIAGRAM
INPUT VOLTAGE
POSITIVE
ZERO
NEGATIVE
+3.0V
0
-4.2V
RAMP TP-A
+1.6V
+0.3V
EXCLUSIVE "OR" TP-B
+15V
-3V
0
TP-C
+15V
-3V
0
TP-D
+1.2V
0
TP-E
+1.6V
0
TP-F
+1.5V MIN.
RESET PULSE TP-M
+12V
ENCODE GATE TP-N

FIGURE 12

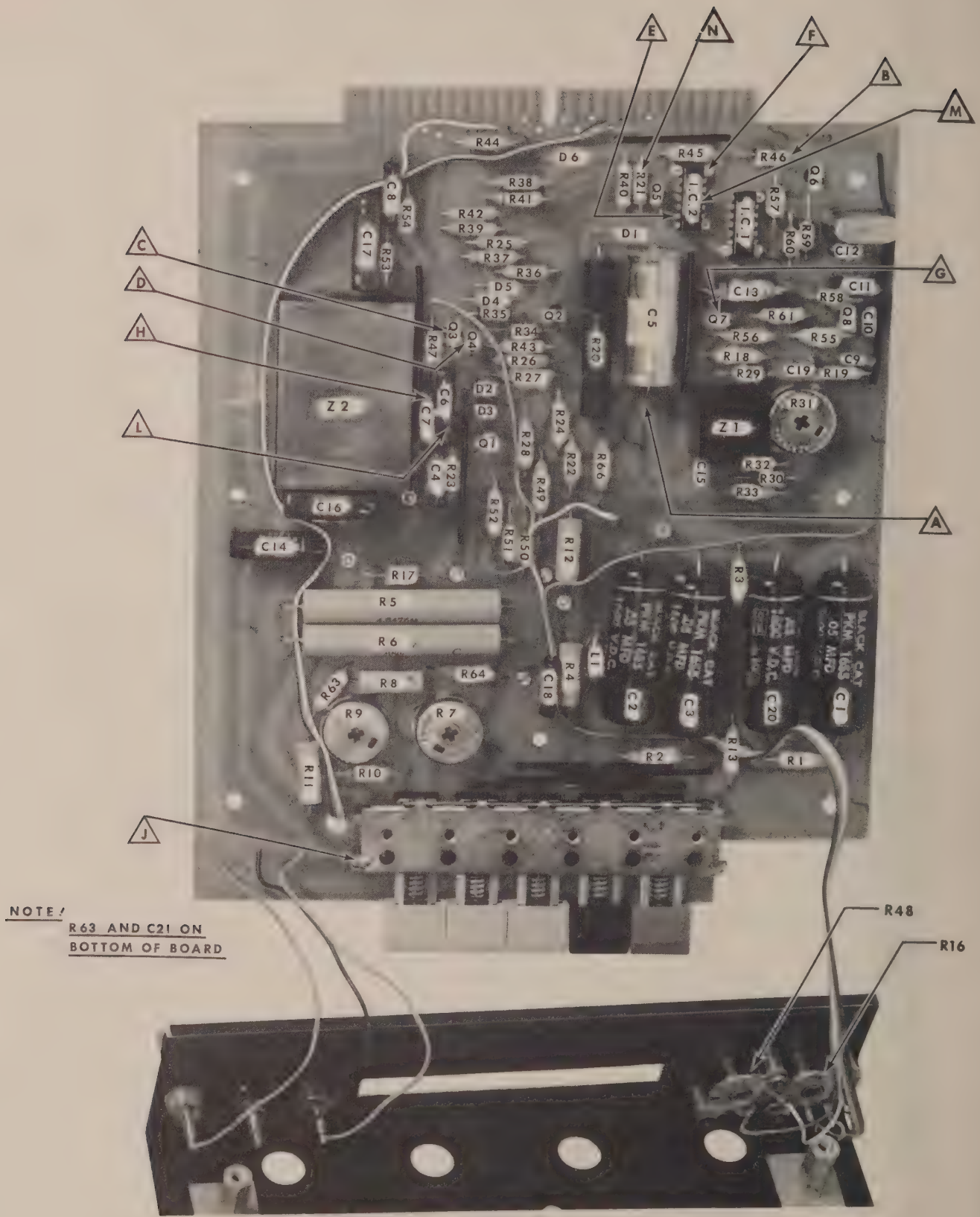

E
N
F
B
M
C
D
H
L
G
A
J
R44
D6
R45
R46
R40
R21
Q5
I.C.2
I.C.1
Q6
R57
R59
R60
C12
C8
R54
C17
R53
R38
R41
R42
R39
R25
R37
R36
D5
D4
R35
Q2
D1
C5
C13
C11
R58
Q7
R61
Q8
C10
R56
R55
R18
C9
R29
C19
R19
R31
Z1
R32
R30
R33
C15
Q3
Q4
R47
R34
R43
R26
R27
R20
C6
C7
Z2
D2
D3
Q1
R24
R22
R66
R28
R49
C4
R23
C16
R52
R51
R50
R12
C14
R17
R5
R6
R3
L1
R4
C18
R64
R8
R63
R9
R7
C2
C3
C20
C1
R2
R13
R1
R11
R10
BLACK CAT
PKM 1665
OF MFD
R48
R16
NOTE!
R63 AND C21 ON
BOTTOM OF BOARD

FIGURE 13

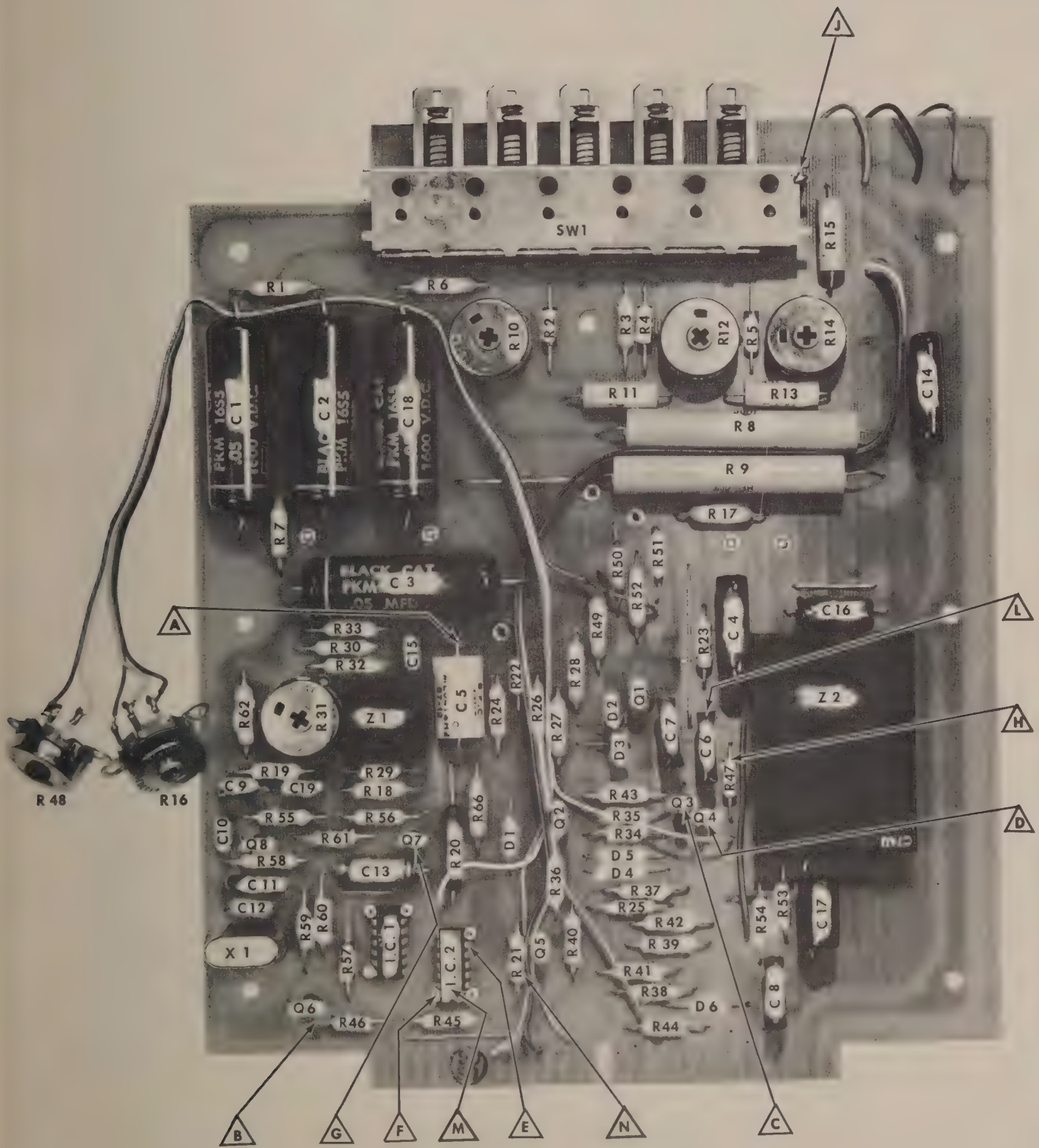

J
SW1
R15
R1
R6
R10
R2
R3
R4
R12
R5
R14
C14
R11
R13
R8
R9
R17
C1
C2
C18
R7
C3
R50
R51
R52
R49
C16
L
A
R33
R30
R32
C15
C5
R22
R26
R28
R23
C4
R62
R31
Z1
R24
R27
Q1
D2
Z2
H
C7
C6
R19
R29
D3
R47
C9
C19
R18
R43
Q3
R48
R16
R55
R56
R66
Q2
R35
Q4
D
C10
Q8
R61
Q7
D1
R34
R20
D5
R58
C13
R36
D4
C11
R37
C12
R25
R54
R53
C17
R59
R60
R42
R40
Q5
R39
X1
I.C.1
I.C.2
R57
R21
R41
R38
C8
Q6
R46
R45
D6
R44
B
G
F
M
E
N
C

FIGURE 14

Notes

Notes

MP MASTER
MA26185